

## Patent Claims

1. Optimisation and simulation CAE-method for determining optimal damping treatments layouts within structural body parts of vehicles, in particular structural body frames, comprising the following input steps to create input variables:

- generating a structural finite element (FE) model of the vehicle body on which damping has to be optimised;
- defining a plurality (N) of possible damping treatments and determining its material characteristic data as well as the body material characteristic data;
- and further comprising the following computing steps:
- applying a genetic algorithm to the above input variables, which algorithm performs a selective iteration by:
  - a) generating a pool of individuals (damping packages/treatment configuration, coded by a binary string) from the input variables (equivalent material damping properties, spatial distribution, thickness, weight, etc. of the binary string);
  - b) mutating (bit change for an individual) and/or crossing (exchange of bit sequences) randomly selected individuals/genes of this pool by means of genetic statistic operators to generate a new generation of individuals/genes;
  - c) selecting each individual of the new generation by means of a statistical selection according to a defined objective function (OF), i.e. calculating the value of a predetermined fitness/priority criterium/predefined targets (lower weight, lower vibration, lower sound pressure level, lower cost, etc./objective function);
  - d) correlating individual's chance of mutating and/or crossing with their performance with respect to the objective function;
  - e) mutating and/or crossing these chance-correlated individuals by means of genetic statistic operators to generate a next new generation of individuals;
  - f) iterating steps c), d) and e) until a predetermined flattening of the slope of the OF versus the number of performed generations is achieved, which leads to a set of optimised vibration damping configurations,

characterised in that this method further comprises the following input steps to create input variables:

- generating further structural finite element (FE) model of the vehicle body comprising structural vehicle body frames and/or panels such as dash, floor or tunnel, on which damping has to be optimised and - in case that an acoustic target/SPL is required - generating a boundary element (BE) model of the passenger compartment;

- defining damping patches potentially subject to possible treatment;
  - defining the plurality (N) of possible damping treatments by including no treatment; and further comprising the following computing steps:
    - Computing the equivalent material damping properties, in particular the overall thickness, weight, porosity, bending-stiffness, elongation stiffness, bending loss factor, elongation loss factor, visco-elasticity, temperature, etc.) by multi-layer simulation, for instance by EMERALD), from these material properties for each combination of any of the plurality of the possible damping treatments with any of the vehicle body panel parameters, including the temperature and frequency dependency of all materials involved;
    - running a FEM simulation, i.e. a finite element model simulation, such as NASTRAN, for a reference configuration in order to calculate the dynamic response in the frequency domain (in particular by using the NVH response transfer function), in particular the vibration behaviour of the vehicle on which damping has to be optimised with respect to excitation, architecture/structure and used materials.
2. Method in accordance with claim 1, characterised in that it relates also to panel shape layouts within structural body parts of vehicles, in particular to determining optimal panel shape layouts within structural panels subjected to structural loads, i.e. determining the optimal geometrical shape layouts of the vehicle body panels under a predefined loading condition, further comprising the following steps:
- defining the areas where a damping treatment is to be applied;
  - defining the surfaces where a shape modification can be performed, and identification of the main dimensions of the geometrical layout of the shape change;
  - defining per each areas of the damping layout and temperature conditions and evaluating of the Equivalent Material properties through Emerald; automatically updating each panel/area of the FE model with the corresponding computed Equivalent Material Properties;
  - automatically updating each surfaces with the corresponding shape layout modification.
3. Method in accordance with one of the claims 1 or 2, characterised in that this method comprises further steps of defining additional constraints or objectives in terms of weight and noise vibration harsh (NVH) performance, in particular in vibration and acoustic pressure.